APPENDIX A
SAMPLING AND ANALYSIS PLAN

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

LIST OF TERMS

bgs	below ground surface
CH2M HILL	CH2M HILL Hanford Group, Inc.
Ecology	Washington State Department of Ecology
FY	fiscal year
RCRA	*Resource Conservation and Recovery Act of 1976*
SAP	Sampling and Analysis Plan
WMA	waste management area

This page intentionally left blank.

A1.0 INTRODUCTION

The focus of this Sampling and Analysis Plan (SAP) is vadose zone investigation of waste management areas (WMAs) C, A-AX, and U, which contain the A, AX, C, and U tank farms. Sampling and analysis of vadose zone sediments will occur in the vicinity of the C, A, and U tank farms to meet the objectives of this investigation.

This plan details the field and laboratory activities to be performed in support of the investigation of vadose zone contamination in WMAs C, A-AX, and U and is designed to be used in conjunction with the work plan and referenced procedures. The field investigations at WMAs C, A-AX, and U addressed in this SAP are to be conducted in fiscal year (FY) 2004 is anticipated to entail:

- Near-surface characterization investigation of UPR-200-E-82 leak area using direct push technology
- Installation of two new vertical exploratory boreholes south of tank C-105 and north of diversion box 241-C152
- Lateral gamma surveys under tanks in A tank farm
- Sediment drill cutting samples collected in conjunction with the installation of proposed *Resource Conservation and Recovery Act of 1976* (RCRA) groundwater monitoring well.

The proposed site-specific investigation to be conducted in FY 2005 is anticipated to entail the installation of two boreholes (one southwest of tank U-104 and one northeast of tank U-112) at WMA U.

Technical procedures or specifications that apply to this work include Duratek Federal Services sampling and geophysical surveying procedures (DFSNW-SSPM-001) and vadose zone characterization at the Hanford Site tank farms, high-resolution passive spectral gamma-ray logging procedures (*Vadose Zone Characterization at the Hanford Tank Farms, High-Resolution Passive Spectral Gamma-Ray Logging Procedures* [P-GJPO-1783]). All field and laboratory work prescribed by this SAP shall also be in conformance with *Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68). Field and laboratory personnel should be familiar with these documents, as appropriate, and maintain a copy for guidance during work activities.

The field activities related to this investigation comprise vadose zone sampling and geophysical logging. This SAP addresses the requirements of the vadose zone sampling and analysis.

The quality assurance project plan, Appendix A of DOE/RL-99-36, is an integral part of this SAP and must be used jointly. Knowledge of the health and safety plan (Appendix B of DOE/RL-99-36) is required by those involved in the field sampling because it specifies procedures for the occupational health and safety protection of project field personnel. The data management plan (Appendix C of DOE/RL-99-36) denotes the requirements for field and laboratory data storage. The waste management plan (Appendix D of DOE/RL-99-36) denotes the requirements for the management of waste and the appropriate collection, characterization, and designation of waste produced by the characterization activities.

PART I
INSTALLATION OF VERTICAL BOREHOLES
(WELL NUMBER TBD)

The following sections provide a discussion of the field tasks and associated subtasks required for the drilling, sampling, and sample analysis associated with the vertical boreholes.

A2.0 PROJECT MANAGEMENT (TASK 1 OF SECTION 5.0)

Project management will be followed as described in DOE/RL-99-36.

A3.0 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF SECTION 5.0)

The geologic and vadose zone investigation task has two subtasks relevant to the installation of the new boreholes: Subtask 2a, field activities, and Subtask 2b, laboratory analysis.
The following subsections describe these subtasks.

A3.1 FIELD ACTIVITIES (SUBTASK 2A OF SECTION 5.0)

The field activities addressed in this subtask required to support the geologic and vadose zone investigation are drilling, geophysical logging, sediment sampling, and reporting activities.

A3.1.1 Drilling Activities

Drilling will be conducted using specifications and guidance in accordance with WAC 173-160. Drilling operations will also conform to SP 4-1, "Soil and Sediment Sampling"; WP 2-2, "Field Cleaning and/or Decontamination of Equipment"; and the task-specific work package that will be generated for these field activities (*Sampling Services Procedures Manual* [DFSNW-SSPM-001]). The work package will contain such information as borehole construction, sampling technique, and radiation protection. All waste will be handled in accordance with the requirements of "Dangerous Waste Regulations" (WAC 173-303) and/or the site-specific waste control plan. These techniques are based on minimizing the exposure of field personnel to both radiation and chemical pollutants to as low as reasonably achievable and in compliance with regulatory requirements.

Current plans for the initial site-specific investigations of WMAs C, A-AX, and U are to install two vertical boreholes in FY 2004 and two vertical boreholes in FY 2005. This initial (Phase 1) site-specific investigation to be conducted in FY 2004 is anticipated to entail the installation of two vertical boreholes near tank C-105 and UPR-200-E-82 and an additional two other boreholes near tanks U-104 and U-112 in FY 2005 for a total of four boreholes.

Vadose zone samples would be collected as the borehole(s) are advanced down to maximum extent of contamination, unless refusal is encountered at WMA C and WMA U. Each borehole has a unique sampling strategy. The sampling strategy is as follows:

- For UPR-200E-82 borehole, near-continuous grab sampling beginning 3 m (10 ft) bgs to the end of technetium-99 and nitrate contamination, with split-spoon samples at 3 m (10 ft) intervals and/or at depths thought to be more moist or at lithology contacts. Grab samples will be collected for chemical analysis at nominal 0.6-m (2-ft) intervals over the length of the borehole. Collect samples for technetium-99 and nitrate water leach analysis at 46 m (150 ft) bgs and 61 m (200 ft) bgs for quick turnaround analysis (approximately 2 days). If technetium-99 and nitrate are not detected, drilling operations will be stopped. If technetium-99 and nitrate are detected at 46 m (150 ft) bgs, collect a sample at 61 m (200 ft) bgs for quick turnaround analysis (2 days). If technetium-99 and nitrate are detected, take a sample at 69 m (225 ft) bgs for quick turnaround analysis. Drilling waits at 69 m (225 ft) for analysis to see if the borehole goes to groundwater. The threshold criteria is detection of 10 pCi/g for technetium-99 or greater in soil for continued drilling deeper for any of these quick turnaround analysis.

- For tank C-105 borehole, near continuous grab samples beginning at 9 m (30 ft) bgs. Collect samples for technetium-99 and nitrate water leach analysis at 46 m (150 ft) bgs and 61 m (200 ft) bgs for quick turnaround analysis (approximately 2 days). If technetium-99 and nitrate are not detected, drilling operations will be stopped. If technetium-99 and nitrate are detected at 46 m (150 ft) bgs, collect a sample at 61 m (200 ft) bgs for quick turnaround analysis (2 days). If technetium-99 and nitrate are detected, take a sample at 69 m (225 ft) bgs for quick turnaround analysis. Drilling waits at 69 m (225 ft) for analysis to see if the borehole goes to groundwater. The threshold criteria is detection of 10 pCi/g for technetium-99 or greater in soil for continued drilling deeper for any of these quick turnaround analysis.

- For tank U-104 borehole, split-spoon samples will be collected every 10 ft beginning at 9 m (30 ft) bgs to the end of technetium-99 and nitrate contamination and/or at depths thought to be more moist or at lithology contacts. Grab samples will be collected for chemical analysis at nominal 0.6 m (2 ft) intervals over entire depth of borehole. Collect samples for technetium-99 and nitrate water leach analysis at 46 m (150 ft) bgs and 61 m (200 ft) bgs for quick turnaround analysis (approximately 2 days). If technetium-99 and nitrate are not detected, drilling operations will be stopped. If technetium-99 and nitrate are detected at 46 m (150 ft) bgs, collect a sample at 61 m (200 ft) bgs for quick turnaround analysis (2 days). Drilling waits at 61 m (200 ft) for analysis to see if the borehole goes to groundwater. The threshold criteria is detection of 10 pCi/g for technetium-99 or greater in soil for continued drilling deeper for any of these quick turnaround analysis.

- For tank U-112 borehole, near continuous grab samples beginning at 9 m (30 ft) bgs to the end of technetium-99 and nitrate contamination (i.e., maximum extent of contamination). One split-spoon sample will be collected at the base of tank depth (approximately 12.8 m [42 ft] bgs). Collect samples for technetium-99 and nitrate water leach analysis at 46 m (150 ft) bgs and 61 m (200 ft) bgs for quick turnaround analysis (approximately 2 days). If technetium-99 and nitrate are not detected, drilling operations will be stopped. If technetium-99 and nitrate are detected at 46 m (150 ft) bgs, collect a sample at 61 m (200 ft) bgs for quick turnaround analysis (2 days). Drilling waits at 61 m (200 ft) for analysis to see if the borehole goes to groundwater. The threshold criteria is detection of 10 pCi/g for technetium-99 or greater in soil for continued drilling deeper for any of these quick turnaround analysis.

This option was selected because vertical boreholes at these locations (i.e., in the vicinity of tanks C-105, U-104, and U-112 and of UPR-200-E-82) would provide source characterization along with distribution of contaminants at the locations of interest from within WMAs C, A-AX, and U. The approximate location of the boreholes in the vicinity of tanks C-105, U-104, and U-112 and of UPR-200-E-82 are shown in Figures A.1 and A.2. At tank C-105, the goal is to drill as near to drywell 30-05-07 as possible. At tank U-104, the goal is to drill as near to drywells 60-07-11, 60-07-10, and 60-07-01. At tank U-112, the goal is to drill as near to drywell 60-12-01 as possible. At UPR-200-E-82, the goal is to drill as near to the pipe joint at line V-122 as possible. These locations are the maximum points of contamination.

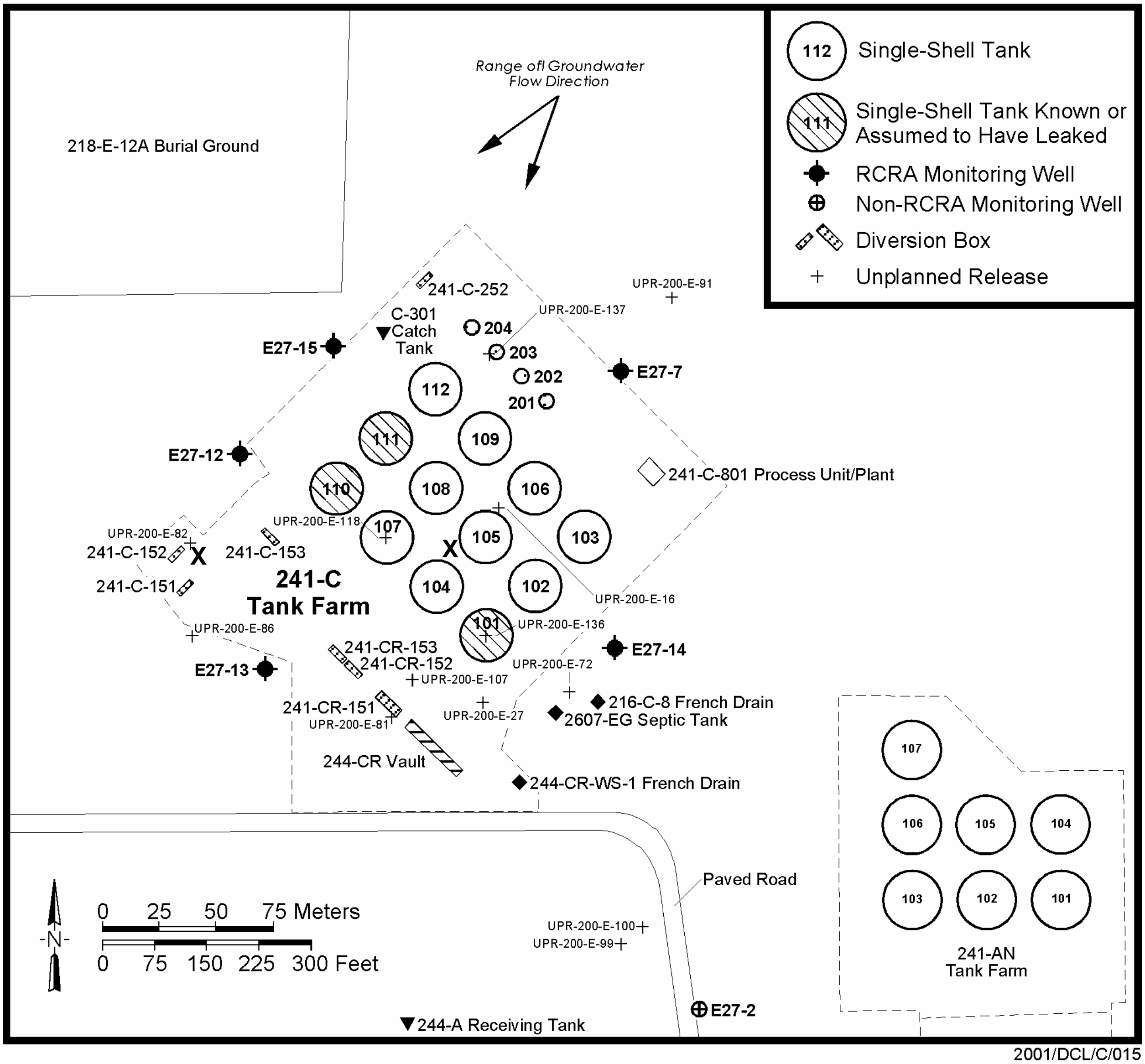
The boreholes would be advanced using a variation of the cable tool method. The final design for the vertical boreholes has not been completed. One of the primary constraints on sample collection could be the potential of a high radiation level, which would limit the sample volumes from that borehole that can be brought to the surface. In addition, logistics will need to be coordinated because tank farm operations may exists in the vicinity of tanks C-105 and U-104 (waste retrieval of tank C-106 and C-104 and waste retrieval of tank U-107).

Subsurface conditions are variable, and the process of installing the vertical boreholes must be flexible. Some or all of the work may require modification. This addendum is intended to serve as a guideline and is designed to allow for changes depending on conditions encountered in the field. Any change will be recorded on the appropriated field documentation, memoranda, or letters. A complete documented record of activities will be maintained for preparation of a final summary report.

Appropriate permits and compliance with the Notice of Construction permit (DOE/ORP-2000-05) will be maintained during the drilling operations inside the tank farm. The selected drilling method will comply with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent contaminated air from being released to the environment.

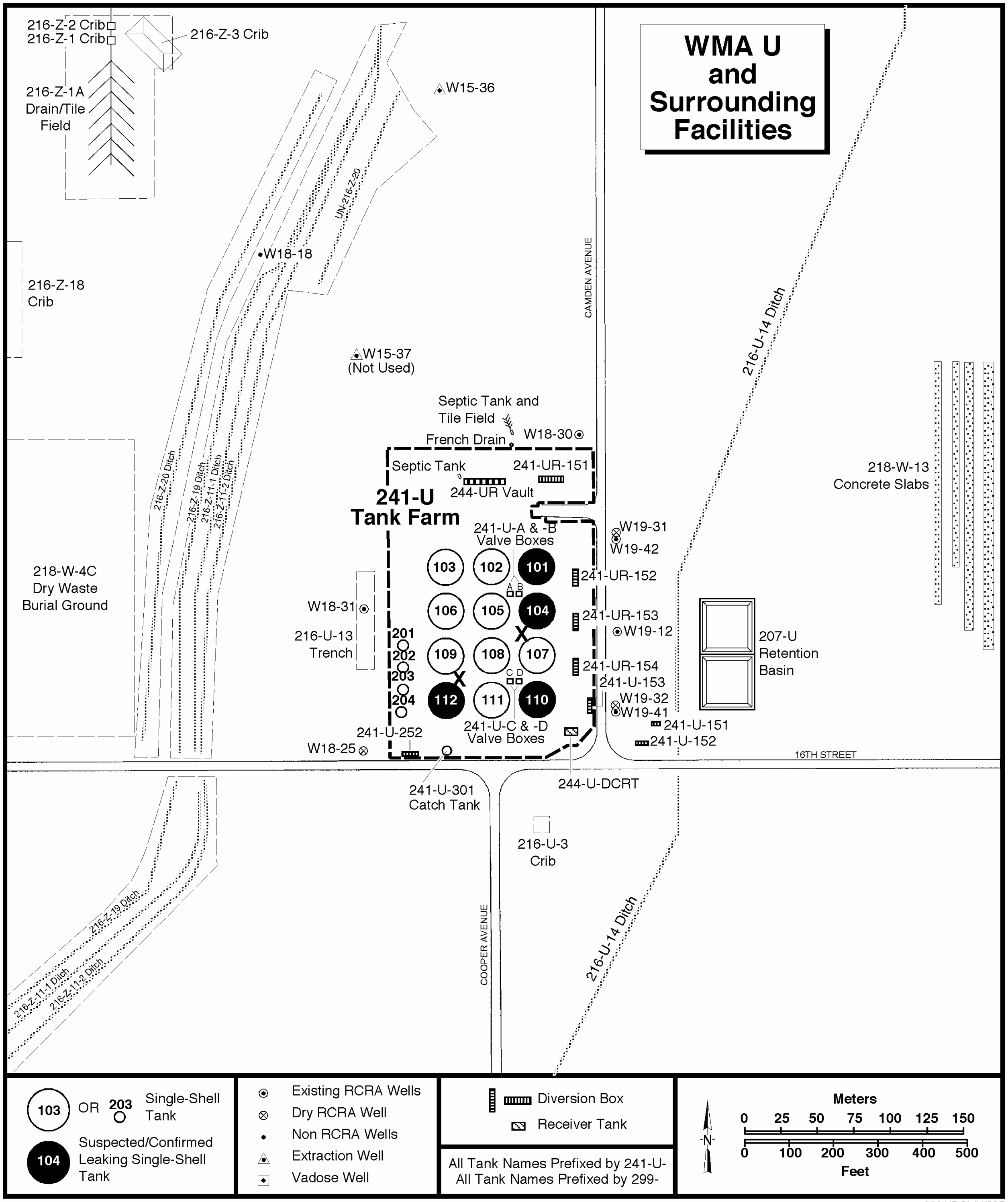
All split-spoon samples will be collected in advance of the casing being driven. Driven split-spoon samples will be attempted at a maximum of every 3-m (10-ft) intervals beginning at 9 m (30 ft) bgs in WMA U and at the borehole at tank C-105 in WMA C. Driven split-spoon samples will be attempted at a maximum of every 3-m (10-ft) intervals beginning at 3 m (10 ft) bgs in WMA C for the borehole located at UPR-200-E-82. The casing is to be driven to total sample depth at the end of each day's drilling effort to prevent potential hole collapse. Split-spoon samplers will be new or decontaminated before reuse. Procedures for decontamination of sampling equipment are contained in WP 2-2, "Field Cleaning and/or Decontamination of Equipment" (*Well Services Procedures Manual* [DFSNW-WSPM-001]).

Figure A.1. Waste Management Area C Proposed Sampling Locations for Vertical Boreholes



X = proposed borehole location.

Figure A.2. Waste Management Area U Proposed Sampling Locations for Vertical Boreholes



X = proposed borehole location.

The depth of the vadose zone borings will be to the maximum extent of contamination unless refusal or perched water is encountered in WMA C and WMA U. If the U.S. Department of Energy desires to continue the borehole through a perched water zone, then the Washington State Department of Ecology (Ecology) would be notified. The use of 2-day turnaround laboratory analyses of water leach samples for technetium-99 and nitrate concentrations is expected to be effective in determining the maximum extent of contamination. A detection of less than 10 pCi/g for technetium-99 will constitute the maximum extent of contamination.

In addition to the borehole geologic logging, radiation measurements will be made using hand-held instruments on each segment of sample recovered during sampling and on the drill cuttings brought to the surface. Blow count measurements will be collected during all drive samples while advancing the split-spoon sampler. General observation will be noted as to drilling progress and problems. All of this information will be included in each borehole geologic log. Borehole geologic logs and well summary sheets will be prepared in accordance with approved Duratek procedures using American Society for Testing and Materials procedures (*Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)* [ASTM D2488]).

A geologist will prepare a geological log for the vertical boreholes, based on the sediment samples. Borehole geologic logs will be prepared in accordance with approved procedures. The geologic log will include lithologic descriptions, sampling intervals, health physics technician hand-held instrument readings, screening results, evidence of any alteration of sediments, and general information and observations deemed relevant by the geologist to the characterization of subsurface conditions. Sediment samples will be screened with hand-held instruments for radiation, as appropriate, using techniques and procedures defined in the work package. Screening results and general observations as to drilling progress and problems will be included in each borehole log.

Waste containing unknown, low-level mixed radioactive waste and/or hazardous waste will be contained, stored, and disposed of in accordance with Appendix D of DOE/RL-99-36, or the most current procedures approved by Ecology, including waste utilizing the area of contaminant approach, and as specified in the quality assurance project plan (Appendix A of DOE/RL-99-36). These activities will be documented in the field activity reports. Waste will be disposed of at the mixed waste burial grounds in accordance with Appendix D of DOE/RL-99-36. All important information will be recorded on field activity report forms per approved procedures. The field activity report form includes the following:

- Borehole number
- Site location drawings
- Downhole tool strings drawing
- List of site personnel
- Sampling types and intervals
- Zones noted as elevated in radiological contaminants by the health physics technician
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole completion.

The new boreholes will be decommissioned in accordance with WAC 173-160 following completion of geophysical surveys. All temporary steel casing removed from a boring will be surveyed and either decontaminated and released or transferred to an appropriate disposal facility. Specific procedures for borehole abandonment will be documented in the field work package. These procedures will comply with U.S. Environmental Protection Agency requirements and WAC 173-160.

Should the contamination extend to groundwater and drilling to groundwater is feasible (i.e., refusal does not occur), the new boreholes may be completed as a RCRA-compliant groundwater monitoring wells. A groundwater sample will be collected and analyzed based on current groundwater analysis for WMAs C and U. Should technetium-99 concentrations exceed 10 times the drinking water standard of 900 pCi/L, or 9,000 pCi/L, a RCRA-compliant groundwater monitoring well will be installed. If so, the new wells may be included in the RCRA groundwater monitoring network for routine groundwater sampling and analysis. If not completed as RCRA-compliant groundwater wells, then the boreholes will be decommissioned in accordance with WAC 173-160 or completed as a vadose zone monitoring well in accordance with WAC 173-160.

If completed as a groundwater monitoring well, a 4-in. stainless steel casing and screen will be permanently installed and a flush mount surface protection/well seal will be constructed. The well will be completed in accordance with WAC 173-160 requirements to meet groundwater protection goals. Specific work steps for well completion will be documented in the tank farm work package.

Contaminant dragdown during drilling and sampling activities is unavoidable and has been observed in recent sampling activities. Different drilling and sampling techniques will impact dragdown to varying degrees. Because the objective of the characterization activities identified in the planning process is to safely sample in and below regions of known leakage, the dragdown issue is a secondary concern. However, appropriate drilling procedures will be used to minimize the effect of contaminant dragdown.

A3.1.2 Geophysical Surveying Activities

Based on sampling and construction methods, downhole spectral-gamma or gross gamma geophysical logging will be conducted to ascertain the gamma-emitting radionuclide concentrations. The spectral-gamma or gross gamma logging frequency will be directed by CH2M HILL Hanford Group, Inc. (CH2M HILL).

A suite of geophysical logs, as determined by the CH2M HILL Field Team Leader, will be run any time the casing size is changed and at the completion of the borehole. This will provide some flexibility with the planning of geophysical logging during the drilling process.

The following logging techniques could be used for the vertical boreholes:

- Gross-gamma logging to support correlation of confining layers and stratigraphy
- Spectral-gamma logging for measuring the distribution of selected radionuclides
- Neutron logging for measuring the relative moisture content.

The existing equipment and procedures for gross-gamma and spectral-gamma logging in use at the Hanford Site provide acceptable data (P-GJPO-1783).

All steel casing will be removed and transferred to an appropriate disposal facility or controlled decontamination facility and released for future use, and each boring will be in accordance to U.S. Environmental Protection Agency requirements and WAC 173-160.

A3.1.3 Sediment Sampling Activities

Borehole sampling will be performed to define the depth of contamination. The borehole will serve to establish the general lithology of the sediments lying below the site and to give indications of how radionuclides and other contaminants have migrated. It also will provide sediment samples for determination of sediment chemistry and vadose zone properties.
This SAP is specific to the borehole and is not applicable to future borehole or shallow soil sampling events.

For the new boreholes soil sampling will begin at 9 m (30 ft) bgs to allow for a limited open borehole and placement of a sealed surface casing, except UPR-200 E-82 borehole, which will begin at 3 m (10 ft) bgs. Drilling and sampling will continue until maximum extent of contamination or refusal. Refusal is defined as 100 blows per foot. Maximum extent of contamination will be based on laboratory measurements for technetium-99 and nitrate water leach analysis. Grab samples will be attempted at a maximum of every 3 m (10 ft) beginning at 9 m (30 ft) bgs for all boreholes except UPR-200-E-82 borehole, which will begin at 3 m (10 ft) bgs because of the occurrence of contamination at this depth. Approximate sample locations will be adjusted to capture locations with elevated or altered gamma or moisture content, any paleosols, and to provide coverage by taking one sample every 3 m (10 ft). Figures A.3 through A.5 show the proposed sampling strategy for the new boreholes at the identified locations.

After the sediment samples are screened, these samples will be transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry group for analysis.
All material removed from the borehole will be sent to the laboratory for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the health physics technician and are to be kept under refrigeration. This process is used to retain sediment moisture in as close to field condition as possible. All samples will be transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Field quality control samples also will be submitted for the full spectrum of chemical and radionuclide analyses. These quality control samples will consist of the following:

- **Equipment rinseate blanks** – One equipment rinseate blank per borehole drilling activity or, if multiple types of samplers are used, once per type of sampler.

Figure A.3. Tank C-105 Borehole Sampling Strategy

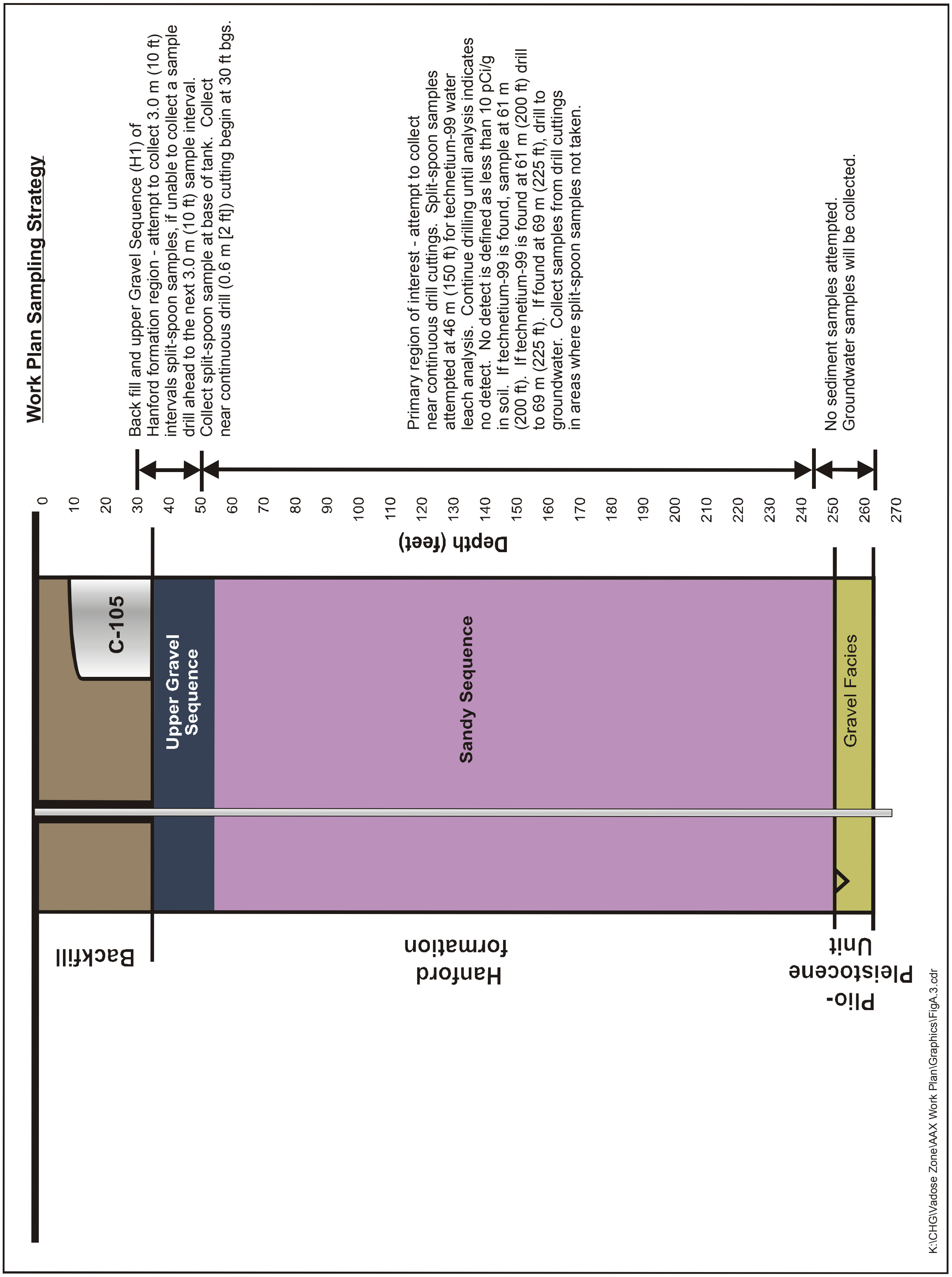


Figure A.4. UPR-200-E-82 Borehole Sampling Strategy

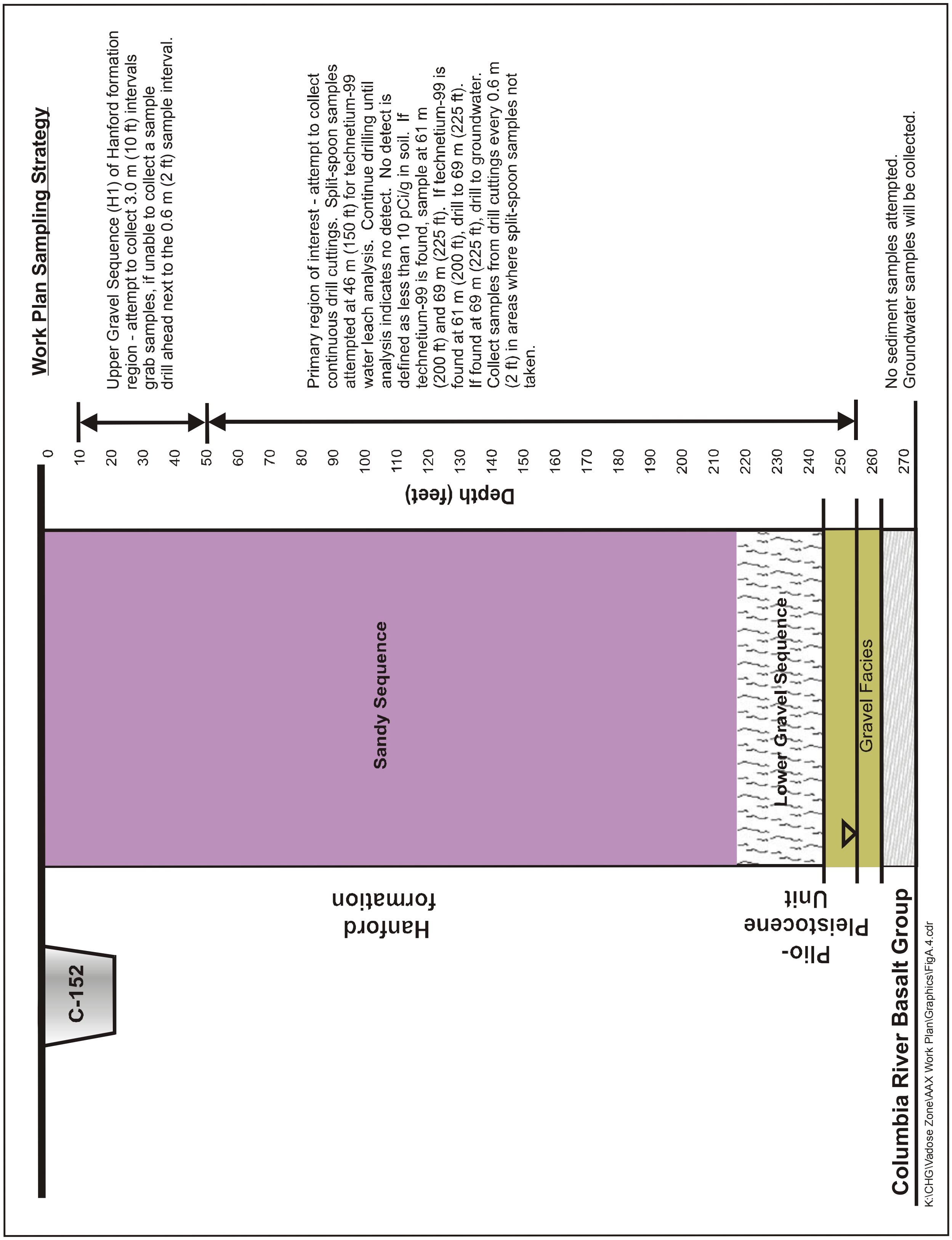
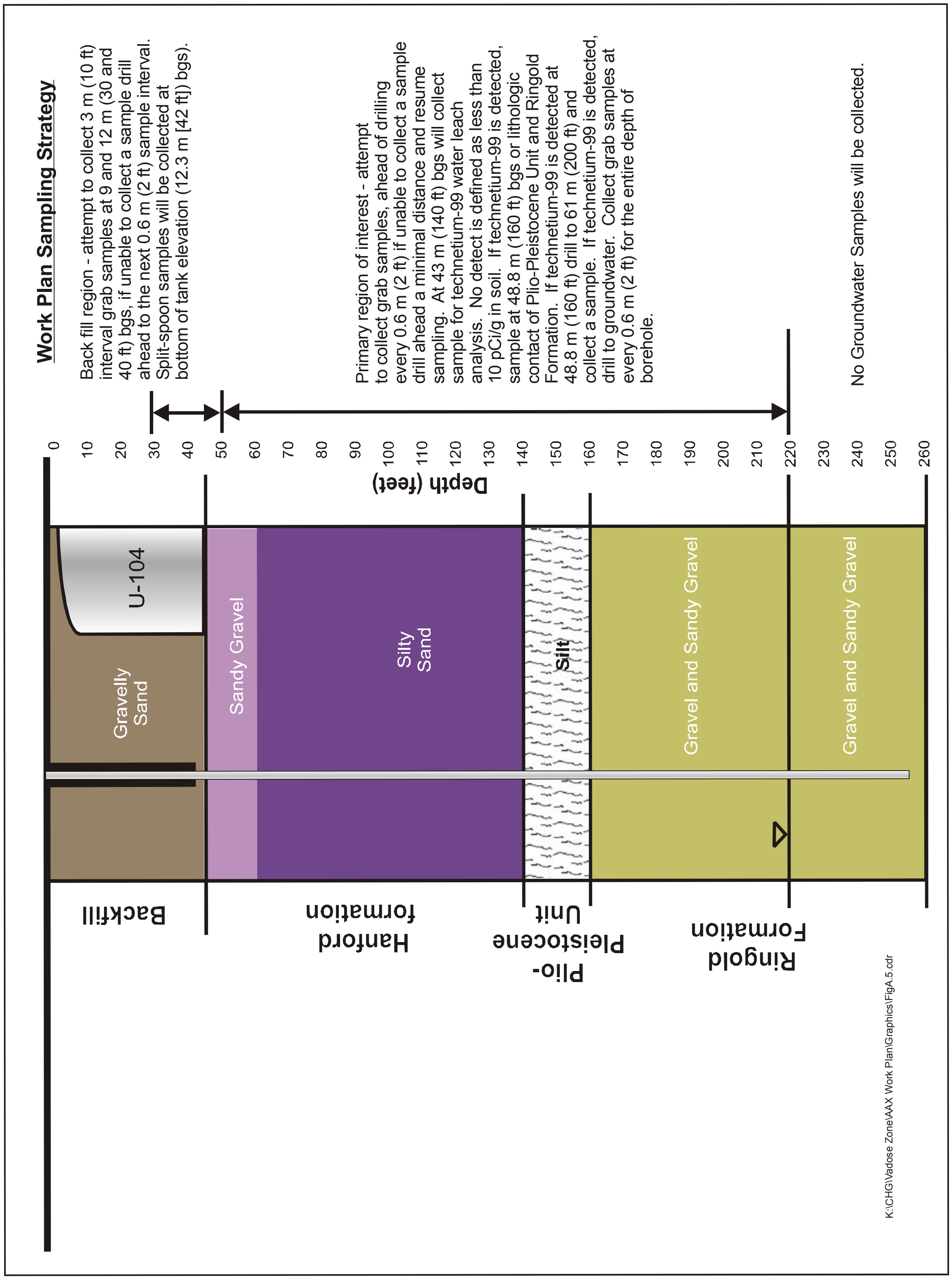


Figure A.5. Tanks U-104 and U-112 Borehole Sampling Strategy



A3.1.4 Groundwater Sampling Activities

No sampling of groundwater will be conducted for these characterization efforts unless contamination extends all the way to groundwater and drilling to groundwater is feasible (i.e., no refusal). If a groundwater sample is collected, analyses will be conducted in accordance with *RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site* (PNNL-13024) and *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U* (PNNL-13612).

A3.1.5 Field Reporting Activities

Field logs will be maintained to record all observations and activities conducted. A site representative will record the activities on a field activity report. Items for entry will include the following:

- Borehole number
- Site location drawings
- Drawings of the downhole tool strings
- Site personnel present
- Sampling types and intervals
- Zones noted by the health physics technician as elevated in radiological contaminants
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole progress and completion.

All completed field records will be maintained and processed in accordance with approved CH2M HILL procedures.

A3.2 LABORATORY ANALYSIS (SUBTASK 2B OF SECTION 5.0)

The following sections describe the laboratory analyses required for the samples collected from the vertical boreholes. Laboratory analyses will be performed on sediment samples in accordance with this SAP. All analytical work prescribed by this SAP will be performed by qualified laboratories with approved quality assurance plans. If the primary contracting laboratory is unable to complete the analyses, it is the primary contracting laboratory's responsibility to subcontract the laboratory work to a qualified secondary laboratory. Samples for laboratory analysis will be placed in appropriate containers and properly preserved in accordance with SP 4-1, "Soil and Sediment Sampling" (DFSNW-SSPM-001), and in accordance with the quality assurance project plan (Appendix A of DOE/RL-99-36). All samples for laboratory analysis will be transported under chain of custody in accordance with the quality assurance project plan.

Sediment cuttings containing low-level and mixed radioactive waste will be contained, stored, and disposed of according to procedures defined in Appendix D of DOE/RL-99-36. Sediment cuttings containing hazardous waste and those containing unknown waste will be contained and disposed of at the mixed waste burial grounds in accordance with Appendix D of DOE/RL-99-36. Storage of archive samples will be done until approval to dispose of the samples is provided by the CH2M HILL technical representative.

Geologic logging for the vertical boreholes will be conducted as it was for the borehole 41-09-39 extension in WMA S-SX (*Preliminary Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA S-SX* [HNF-4380]). Specifically, once sample material from the vertical boreholes is received at the laboratory, it will be geologically logged by an assigned geologist in general conformance with standard procedures. The assigned geologist will photograph the samples and describe the geologic structure, texture, and lithology of the recovered samples. Special attention is to be paid to the presence of contaminant alteration. If such a phenomenon is noted, that sample will be noted, preserved for more detailed physical, chemical, and mineralogic analyses, and recorded in the laboratory notebook.

Sediment subsamples for laboratory analysis will be defined by location in the sample after the field screening and geologic logging have been completed and indication of contamination locations have been identified. Approximately 23 sediment subsamples from each of the boreholes in WMA C will be chosen for screening analysis and approximately 12 sediment subsamples from each of the boreholes in WMA U will be chosen for screening analysis. The following criteria will be used to identify samples for laboratory analysis based on concurrence with Ecology:

- One background sample will be taken at 9 m (30 ft) bgs.
- One sample will be taken at 12.2 m (40 ft) bgs, at the level of the tank bottom.
- If drilled to groundwater, one sample will be taken at the Hanford formation and Hanford formation/Undifferentiated Plio-Pleistocene Silt/Ringold Formation Mud? [Pplz/R(?)]) Unit interval contact at approximately 76.2 m (250 ft) bgs in WMA C.
- One sample will be taken at the Hanford formation interval and Plio-Pleistocene unit contact at approximately 43 m (140 ft) bgs in WMA U.
- Samples will be taken of any paleosols seen in the split-spoon drive samples.
- Samples will be taken in locations where elevated or altered gamma surveying or moisture content was measured during the geological and geophysical borehole logging process
- At least one sample will be taken every 0.6 m (2 ft) if samples have not already been taken, based on the above criteria to ensure continuous distribution and lithologic completeness.

Figures A.3 through A.5 show the samples identified for laboratory analyses. Worker safety considerations may limit the collection of samples at certain intervals. A 1:1 water extract of all samples shall undergo screening analyses. Screening analyses comprise the following:

- Nitrate analysis by the colorimetric method
- Electrical conductance
- Total organic carbon/total carbon
- gamma energy analysis

- pH
- Technetium-99.

These analyses, along with the gamma surveying and moisture content measurements performed during the field geophysical surveys and the laboratory geologic logging, will be used to determine the extent of further sample analysis. Table A.1 identifies the full complement of potential analyses and their respective laboratory preparation and analytical methods. This paragraph and the remainder of this appendix identify which analysis will be conducted on which sample. If more than one preparation or analytical method is listed, the expertise of the laboratory geochemistry staff will be used to determine which methods will produce the best results and will provide the best understanding of the chemistry involved. For those methods that produce multiple constituents (i.e., inductively coupled plasma), all constituents identified will be reported. Every effort is to be made to meet regulatory holding times where appropriate. The planning process identified the need for volatile organic analysis and semivolatile organic analysis. An attempt will be made to perform these analyses; however, based on experience from WMA S-SX, it is unlikely that the holding time for volatile organic analysis can be met. If holding times cannot be met, analysis of these compounds will not be performed. Based on previous experience, it is anticipated that holding times for the semi-volatile organic analysis can be met.

Because the purpose of the new borehole analyses is to gain an understanding of the nature and extent of contamination, the fate and transport of the contaminants in the vadose zone and to produce RCRA-compliant data, the analysis of these subsamples comprises two levels. The baseline level involves analysis of organic, inorganic, and radiochemical constituents in full conformance with DOE/RL-96-68 and with no modifications to methods (as defined by DOE/RL-96-68) without concurrence from the CH2M HILL technical representative and from Ecology. Substitutions and deviations to methods as defined in DOE/RL-96-68 will require concurrence from Ecology. The second level involves a research-type approach to the analyses. In this level, procedures may be modified or developed to gain a more comprehensive understanding of the dynamics involved. Although specific quality control criteria do not apply to this level, compliance with the other quality assurance requirements in DOE/RL-96-68 must still be met and research analysis will be initiated only following review and approval of the activities by the CH2M HILL technical representative.

The background subsample, backfill – Hanford formation contact subsample, Hanford formation H1 unit and Hanford formation H2 unit contact sample, peak gamma concentration sample, the two subsamples obtained at the Hanford formation and Plio-Pleistocene unit interval contact in WMA U, the Hanford formation interval and Undifferentiated Plio-Pleistocene Silt/Ringold Formation Mud? [Pplz/R(?)]) Unit interval contact in WMA C will be analyzed for the constituents and properties identified in Table A.1. It is recognized that conditions may occur when all of the analyses identified in Table A.1 are not warranted (e.g., limited potential for data) and these occurrences will be evaluated on a case-by-case basis.

At the request of Ecology for boreholes located in close proximity to tanks, three samples at 9 m (30 ft), 12.2 m (40 ft), and 15.2 m (50 ft) at or near the base of the tank will be analyzed for volatile and semivolatile organics identified in Tables A.1 and A.2. No volatile or semivolatile organics sample will be collected for UPR-200-E-82 borehole.

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Radionuclide		RR[a] pCi/g	C/I[a] pCi/g	GW[a, g] pCi/L		pCi/L	pCi/L	pCi/g	pCi/g				
Americium-241	14596-10-2	31	210	TBD	Americium Isotopic - Alpha Energy Analysis (AEA)	1	400	1	4000	+-20%	70-130%	+-35%	70-130%
Carbon-14	14762-75-5	5.2[f]	33100	TBD	Carbon-14 - Liquid Scintillation	200	N/A	50	N/A	+-20%	70-130%	+-35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	Gamma Energy Analysis	15	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	Gamma Energy Analysis	25	200	0.05	2000	+-20%	70-130%	+-35%	70-130%
Europium-152	14683-23-9	3.3	12	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-154	15585-10-1	3	11	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Europium-155	14391-16-3	125	449	TBD	Gamma Energy Analysis	50	200	0.1	2000	+-20%	70-130%	+-35%	70-130%
Hydrogen-3	10028-17-8	359[f]	14200	20000	Tritium - Liquid Scintillation	400	400	400	400	+-20%	70-130%	+-35%	70-130%
Neptunium-237	13994-20-2	2.5	62.2	TBD	Neptunium-237 - AEA	1	N/A	1	8000	+-20%	70-130%	+-35%	70-130%
Nickel-63	13981-37-8	4026	3008000	TBD	Nickel-63 - Liquid Scintillation	15	N/A	30	N/A	+-20%	70-130%	+-35%	70-130%
Plutonium-238	13981-16-3	37	483	15	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Radionuclide (Cont'd)		RR[a] pCi/g	C/I[a] pCi/g	GW[a, g] pCi/L		pCi/L	pCi/L	pCi/g	pCi/g				
Plutonium-239/240	PU-239/240	34	243	15	Plutonium Isotopic - AEA	1	130	1	1300	+-20%	70-130%	+-35%	70-130%
Total Radioactive Strontium	SR-RAD	4.5	2500	8	Total Radioactive Strontium - Gas Proportional Counting (GPC)	2	80	1	800	+-20%	70-130%	+-35%	70-130%
Technetium-99	14133-76-7	5.7[f]	410000	900	Technetium-99 - Liquid Scintillation	15	400	15	4000	+-20%	70-130%	+-35%	70-130%
Thorium-232	TH-232	1	5.1	15	Thorium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-234	13966-29-5	160	1200	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-235	15117-96-1	26	100	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%
Uranium-238	U-238	85	420	15	Uranium Isotopic - AEA (pCi) ICPMS (mg)	1	.002 mg/L	1	0.02 mg/Kg	+-20%	70-130%	+-35%	70-130%

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics													
Ethyl alcohol	64-17-5	None	None	None	Non-Halogenated VOA - 8015c – GC	5	N//A	5	N/A	e	e	e	e
n-Butyl alcohol	71-36-3	8000	350	160	Non-Halogenated VOA - 8015 - GC	5	N/A	5	N/A	e	e	e	e
Methyl alcohol (methanol)	67-56-1	40000	160000	400	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	1	N/A	1	N/A	e	e	e	e
Kerosene (paraffin hydrocarbons)	8008-20-6	200000[h]	200000[h]	200000[h]	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	5	5	e	e	e	e
Carbon tetrachloride	56-23-5	7.69	224	0.0337	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-Propanone (Acetone)	67-64-1	8000	32000	80	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
Chloroform	67-66-3	164	3200	0.717	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Benzene	71-43-2	34.5	1380	0.151	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,1-trichlorethane	71-55-6	72000	288000	720	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Dichloromethane (methylene chloride)	75-09-2	133	5330	0.583	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Carbon Disulfide	75-15-0	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1-dichloroethane	75-34-3	8000	32000	80	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1-dichloroethene	75-35-4	1.67	66.7	0.00729[f]	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,2-dichloropropane	78-87-5	14.7	588	0.0643	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-butanone	78-93-3	48000	192000	480	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
1,1,2-trichloroethane	79-00-5	17.5	702	0.0768	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2-trichloroethylene	79-01-6	90.9	3640	0.398	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethane	79-34-5	5	200	0.0219	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Ethyl benzene	100-41-4	8000	32000	80	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,2-dichloroethane	107-06-2	11	440	0.0481	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
4-methyl-2-pentanone	108-10-1	6400	25600	64	Volatile Organics - 8260 - GCMS	0.01	0.01	0.01	0.01	e	e	e	e
Toluene	108-88-3	16000	64000	160	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Chlorobenzene	108-90-7	1600	6400	16	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethene	127-18-4	19.6	784	0.0858	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
2-hexanone	591-78-6	None	None	64	Volatile Organics - 8260 - GCMS	0.02	0.02	0.02	0.02	e	e	e	e
cis-1,3-dichloropropene	10061-01-5	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Trans-1,3-dichloropropene	10061-02-6	5.56	96	0.0243[i]	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Xylene (total)	1330-20-7	160000	640000	1600	Volatile Organics - 8260 - GCMS	0.005	0.005	0.005	0.005	e	e	e	e
Dibenz[a,h]anthrax-cene	53-70-3	0.137[f]	5.48	0.0012[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachloroethane	67-72-1	71.4	320	0.625	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Hexachlorobutadiene	87-68-3	12.8	64	0.0561[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Pentachlorophenol	87-86-5	8.33	333	0.0729[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2-methylphenol (o-cresol)	95-48-7	4000	16000	80	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2-dichlorobenzene	95-50-1	7200	28800	72	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Nitrobenzene	98-95-3	40	160	0.8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
4-methylphenol (p-cresol)	106-44-5	400	1600	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,4-dichlorobenzene	106-46-7	41.7	1670	0.0182[f]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Pyridine	110-86-1	80	320	1.6	Semi-Volatiles - 8270 - GCMS	0.02	0.1	0.66	2	e	e	e	e
Hexachlorobenzene	118-74-1	0.625	25	0.00547[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
1,2,4-trichlorobenzene	120-82-1	800	3200	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4-Dinitrotoluene	121-14-2	160	640	3.2	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Tributyl phosphate	126-73-8	None	None	None	Semi-Volatiles - 8270 - GCMS	0.1	0.5	3.3	5	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
1,3-dichlorobenzene	541-73-1	41.7	1670[j]	0.018[f,j]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Benzo(a)pyrene	50-32-8	0.137f	5.48	0.0012[o]	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
2,4,5-Trichlorophenol	95-95-4	8000	32000	160	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e	e
Gamma-BHC (Lindane)	58-89-9	0.769	30.8	0.00673	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Dieldrin	60-57-1	0.0625	2.5	0.000547[o]	Pesticides - 8081 - GC	0.0001	N/A	0.0033	N/A	e	e	e	e
Endrin	72-20-8	24	96	0.48	Pesticides - 8081 - GC	0.0001	N/A	0.0033	N/A	e	e	e	e
Heptachlor	76-44-8	0.222	8.89	0.00194	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Aldrin	309-00-2	0.0588	2.35	0.000515[f]	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Alpha-BHC	319-84-6	0.159	6.35	0.00139[f]	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Beta-BHC	319-85-7	0.556	2.22	0.00486	Pesticides - 8081 - GC	0.00005	N/A	0.00165	N/A	e	e	e	e
Toxaphene	8001-35-2	0.909	36.4	0.00795[o]	Pesticides - 8081 - GC	0.005	N/A	0.165	N/A	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Organics (Cont'd)													
Total Organic Carbon	TOC	N/A	N/A	None	TOC - 9060- Combustion	1	1	100	100	+-20%	70-130%	+-35%	70-130%
Polychlorinated biphenyls (PCBs)	1336-36-3	0.13	5.19	0.00114[o]	PCBs - 8082 - GC	0.0005	0.005	0.0165	0.1	e	e	e	e
Inorganics													
Ammonia/ammonium	7664-41-7	2720000	10900000	27100	Ammonia - 350.Nd	0.05	800	0.5	8000	e	e	e	e
Phosphate	14265-44-2	N/A	N/A	None	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Nitrate	14797-55-8	128000	512000	2560	Anions - 9056 - IC	0.25	10	2.5	40	e	e	e	e
Nitrite	14797-65-0	8000	32000	160	Anions - 9056 - IC	0.25	15	2.5	20	e	e	e	e
Sulfate	14808-79-8	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.5	15	5	40	e	e	e	e
Chloride	16887-00-6	25000[k]	25000[k]	25000	Anions - 9056 - IC	0.2	5	2	5	e	e	e	e
Fluoride	16984-48-8	96[k]	200[k]	96	Anions - 9056 - IC	0.5	5	5	5	e	e	e	e
Bromide	24959-67-9	N/A	N/A	None	Anions - 9056 - IC	0.25	N/A	2.5	N/A	e	e	e	e
Chromium VI	18540-29-9	400	1600	8	Chromium (hex) - 7196 - Colorimetric	0.01	4	0.5	200	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7470 - CVAA	0.0005	0.005	N/A	N/A	e	e	e	e
Mercury	7439-97-6	24	96	0.48	Mercury - 7471 - CVAA	N/A	N/A	0.2	0.2	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Nickel	7440-02-0	1600	6400	32	Metals - 6010 - ICP	0.04	0.04	4	4	e	e	e	e
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP	0.02	0.02	2	2	e	e	e	e
Antimony	7440-36-0	32l	128l	6	Metals - 6010 - ICP	0.06	0.12	6	12	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP	0.2	0.2	20	20	e	e	e	e
Beryllium	7440-41-7	0.233	9.3	0.00203[o]	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP	0.005	0.01	0.5	1	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP	0.01	0.01	1	2	e	e	e	e
Copper	7440-50-8	2960	11800	59.2	Metals - 6010 - ICP	0.025	0.025	2.5	2.5	e	e	e	e
Selenium	7782-49-2	400	1600	8[f]	Metals - 6010 - ICP	0.1	0.2	10	20	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Chemical		Meth B mg/Kg	Meth C mg/Kg	mg/Kg		mg/L	mg/L	mg/Kg	mg/Kg				
Inorganics (Cont'd)													
Lead	7439-92-1	25000[h]	25000[h]	N/A	Metals - 6010 - ICP (TRACE)	0.01	N/A	1	N/A	e	e	e	e
Silver	7440-22-4	400	1600	8	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Antimony	7440-36-0	32l	128l	6	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Arsenic	7440-38-2	6.5[m]	66.7	0.00583[o]	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Barium	7440-39-3	5600	22400	112	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	Metals - 6010 - ICP(TRACE)	0.005	N/A	0.5	N/A	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
Selenium	7782-49-2	400	1600	8	Metals - 6010 - ICP(TRACE)	0.01	N/A	1	N/A	e	e	e	e
PH	pH	N/A	N/A	None	pH - 9045 - Electrode	N/A	N/A	N/A	N/A	e	e	e	e
Sulfides	18496-25-8	N/A	N/A	None	Sulfide - 9030 - Colorimetric	0.5	N/A	5	N/A	e	e	e	e
Cyanide	57-12-5	1600	6400	32	Total Cyanide - 9010 - Colorimetric	0.005	0.005	0.5	0.5	e	e	e	e

Table A.1. Constituents and Methods for Sediment Sample Analyses for Waste Management Areas C, A-AX, and U (11 Sheets)

CoC	CAS No.	Action Levels			Name/ Analytical Tech.	Target Required Quantitation Limits				Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
						Water[b] Low Level	Water[b] High Level	Soil-Other Low Level	Soil-Other High Level				
Inorganics (Cont'd)													
Uranium (total)	7440-61-1	240[n]	960[n]	4.8	Uranium Total - Kinetic Phosphorescence Analysis	0.0001	0.02	1	0.2	+-20%	70-130%	+-35%	70-130%

[a]RR - Rural Residential, C/I – Commercial Industrial, GW - Groundwater Protection Radionuclide values from WDOH "Hanford Guidance for Radiological Cleanup," WDOH/320-015. Radionuclide values are calculated using parameters from WDOH guidance.
[b]Water values for sampling QC (e.g., equipment blanks/rinses) or drainable liquid (if recovered).
[c]All four-digit numbers refer to "Test Methods for Evaluating Solid Waste" (EPA SW-846).
[d]"Methods of Analysis of Water and Waste" (EPA-600/4-79-020).
[e]Precison and Accuracy Requirements as identified and defined in the referenced U.S. Environmental Protection Agency procedures.
[f]If quantitation to action level lower than nominal RDL is required, prior notification/concurrence with the laboratory will be required to address special low-level detection limits.
[g]The 100 times GW rule does not apply to residual radionuclide contaminants. GW protection is demonstrated through technical evaluation using RESRAD (DOE/RL-96-17, Rev. 2).
[h]This value is based upon MTCA Method A values.
[i]Value based upon most restrictive dichlorpropene 1,3.
[j]Value based upon most restrictive dichlorobenzene compound.
[k]Value based upon soil concentration for groundwater protection RAGs.
[l]Value based upon most restrictive antimony compound.
[m]Default to background.
[n]Value based upon uranium soluble salts value.
[o]Detection limits below this value not achievable by listed technology. No routine technology likely available to achieve this detection limit.

Table A.2. Constituents and Methods for Organic Analysis of Borehole Sediment Samples

Analysis/ Constituent	Preparation Method	Preparation Procedure Number	Analytical Method	Analytical Procedure Number
VOA	Bulk Sediment	Note 1	GC/MS	SW846-8260
SVOAs with TICs	Bulk Sediment	Note 1	GC/MS	SW846-8270

Note 1: Preparation/extraction procedures for VOA and SVOA analysis will depend on the types of organic compounds present in the sediment.

GC = gas chromatography
MS = mass spectrometry
SVOA = semi-volatile organic analysis
VOA = volatile organic analysis

The remaining samples will be analyzed for specific constituents listed in Table A.1 depending on the results of the nitrate, electrical conductivity, total organic carbon/total carbon, and pH screening analyses. A review of the screening analyses results with technical representatives along with Ecology will be conducted before performing additional analyses. Screening analysis may be used to determine whether alternative analytical techniques with lower detection limits should be used for specific radionuclides of concern. The screening criteria and associated analytical requirements are identified as follows:

- Gamma-emitting radioisotopes by gamma energy analysis
- Metals and radioisotopes by inductively coupled plasma-mass spectrometry
- Tritium and strontium-90 by the liquid scintillation method
- Particle size distribution
- Carbon-14.

At the request of Ecology, a minimum of two samples collected within the Hanford formation will be analyzed for metals as identified in Table A.1.

The data obtained from the above analyses will be used to evaluate the location of contamination plumes in the sediment column. The results of the above analyses will also be used to determine if additional analyses are warranted. Additional analyses would be performed based on the judgment and expertise of the responsible Pacific Northwest National Laboratory geochemist, with concurrence from the CH2M HILL technical representative and Ecology. The following analyses would be performed as additional analyses:

- Cation exchange capacity
- Mineralogy
- Matric potential
- Distribution coefficient
- Bulk density
- Moisture retention
- Saturated hydraulic conductivity.

Tables A.1 and A.2 identifies the analyses and laboratory methods to be used for the sample analyses. For the chemical and radiological constituents, the preferred methods are those listed in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA SW-846) or *Standard Test Methods for Materials* (ASTM 1998). The requested constituents may be analyzed by laboratory-specific procedures, provided that the procedures are validated and conform to requirements in DOE/RL-96-68. Both the EPA SW-846 methods and the Pacific Northwest National Laboratory methods listed in Tables A.1 and A.2 are based on techniques from "Methods of Soil Analysis." Therefore, these procedures should be comparable.

PART II
NEAR-SURFACE CHARACTERIZATION

The following is a discussion of the field tasks and associated subtasks required for the sampling and sample analysis associated with the near-surface characterization in WMA C. The tasks are generally parallel to those addressed for the vertical boreholes.

A4.0 PROJECT MANAGEMENT (TASK 1 OF CHAPTER 5.0)

Project management will be followed as described in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

A5.0 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF CHAPTER 5.0)

As with installation of the vertical boreholes, the geologic and vadose zone investigation task for the near-surface characterization has two subtasks: Subtask 2a, field activities, and Subtask 2b, laboratory analysis. The following subsections describe each of the subtasks with a field activity component.

A5.1 FIELD ACTIVITIES (SUBTASK 2A OF CHAPTER 5.0)

The field activities addressed in this subtask that are required to support the geologic and vadose zone investigation are geophysical surveying, sediment sampling, and reporting.

A5.1.1 Exploratory Activity

One area has been identified for the Phase 1 near-surface vadose zone soil characterization. The area is east and north of diversion box 241-C-152 in the C tank farm. Because of the high cesium content near the surface, the area directly related to the unplanned release will not be investigated. Using gamma survey data to define the lateral limits of the plume, direct push technology will be used to investigate lateral extent of technetium-99 leak area using direct push technology. The direct push technology pushes would focus on distribution along the pipe and perpendicular to the pipeline. Depending on technology used, soil sample size may constitute only analyzing for water leachable constituents such as nitrate as an indicator for technetium-99 migration and non destruct GEA prior to water extraction. Soil sampling size directly impacts amount of analysis. A minimum of 30 grams of sample is required to do key Tier 1 analysis. With between 150 to 200 grams can do entire suite. Perform gamma logging in all direct-push holes.

A total of 20 push sites have been identified.

The shallow investigation of this area will comprise collecting sediment samples at approximately 20 locations. Sediment samples would be attempted from the tank farm surface to refusal using direct-push technology. Although near-surface characterization is focused typically on the upper 4.6 m (15 ft), the sampling methods have the capability to sample deeper and provide additional data for the characterization effort.

Direct-push deployment at the shallow zone characterization locations would include the following.

- Shallow soil characterization will be carried out using a truck-mounted direct-push technology-based system.

- Deployment and interrogation with a gross-gamma/spectral gamma probe. The depth of investigation will be determined by the depth to which the direct-push boring can be advanced using a standard deployment truck. The probe will be deployed using the gross gamma mode with the tool advanced at approximately 2 cm/sec (0.8 in./sec). Based on regulatory requirements, if in the upper 5 m (15 ft) the downhole instrument indicates a potential cesium-137 concentration of 3.7 pCi/g or greater, logging will be shifted to the spectral mode to determine the presence and level of concentration of cesium-137; below 5 m (15 ft) bgs the threshold limit for spectral gamma determinations will be 20 pCi/g. In zones where cesium-137 is present at concentrations greater than 20 pCi/g, spectral gamma readings will be taken at 0.5-m (1.5-ft) intervals.

- The graphical log developed using the gross and spectral gamma measurements will be used to select intervals to be sampled.

- The sampling push is to be made in a location that is no more than 0.7 m (2 ft) from the site of the gamma push.

- A single point sampler will be used to collect the required samples. Sampling intervals will be selected from those horizons with a cesium-137 concentration of 20 pCi/g or greater. In the event that horizons are penetrated that would yield samples having a greater that 50 mrem/hr dose rate at 30 cm (12 in.) (based on calculations using sampler size and cesium-137 concentration) a sample will be collected from the first interval below the high rate zone having a dose rate of less than 50 mrem/hr. No sample will be collected from zones where the gamma instrument exhibits excessive deadtime.

- The samples would be transported to the laboratory and analyzed for the contaminants of concern identified in Table A.1.

The samples selected for analysis would be subject to screening analyses, which consist of nitrate analysis by colorimetric method, pH, electric conductance, and gamma energy analysis. Based on the results of the screening, the samples would be analyzed for the remaining contaminants of concern identified in Table A.1.

A5.1.2 Field Quality Control

After the samples are screened, these samples will be transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry group for analysis. All material removed from the push holes will be sent to the laboratory for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the health physics technician and are to be kept under refrigeration. This process is used to retain sediment moisture in as close to field condition as possible and prevent chemical and physical changes from occurring. All samples will be transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Field quality control samples also will be submitted for the full spectrum of chemical and radionuclide analyses. These quality control samples will consist of the following:

- Equipment rinseate blanks: One equipment rinseate blank per each type of sampler or, if multiple types of samplers are used, once per type of sampler.

A5.1.3 Geophysical Surveying Activities

Prior to sediment sampling using the direct push, downhole gross gamma and spectral gamma geophysical surveying will be conducted to ascertain the gamma-emitting radionuclide concentration in the surrounding sediments. After each push with the direct push or each borehole with the hollow-stem auger, decommissioning will occur.

A5.1.4 Field Reporting Activities

Field logs will be maintained to record all observations and activities conducted. A site representative will record the activities on a field activity report. Items for entry will include the following:

- Direct push or borehole number
- Site location drawings, including distances from known locations
- Drawings of the downhole tool strings for direct push
- Site personnel present
- Sampling types and intervals
- Zones noted by the health physics technician as elevated in radiological contaminants
- Instrument readings and the depth represented by those readings
- Specific information concerning borehole completion.

All completed field records will be maintained and processed in accordance with approved CH2M HILL Hanford Group, Inc. procedures.

A5.2 LABORATORY ANALYSIS (SUBTASK 2B OF CHAPTER 5.0)

The following sections describe the laboratory analyses required for the samples collected from the near-surface characterization.

A5.2.1 Near-Surface Characterization Sediment Sample Analysis Requirements

A total of approximately 20 site locations have been identified for the near-surface characterization effort. Once received at the laboratory, these samples shall undergo analysis using the analytical methods listed in Table A.1. This analysis may be sample-limited. Therefore, hold points have been inserted into the process to allow the laboratory and CH2M

HILL Hanford Group, Inc. technical staff to collaborate and review data before each new round of analyses. Analyses may be reprioritized based on the results of other measurements.

Based on the results of the screening analyses that were identified in the vertical boreholes, and spectral gamma surveys performed during the field geophysical surveys, and the geologic logging and field notes, geological technical experts, CH2M HILL Hanford Group, Inc. technical staff, the laboratory technical staff, and decision-makers (Ecology and the U.S. Department of Energy) will convene to determine what, if any, additional analyses should be conducted. Some of the determining criteria will be the amount and integrity of the remaining sample, screening analytical results, and regulatory requirements. Based on these decisions, additional analyses will be performed.

PART III
LATERAL CHARACTERIZATION

The following sections provide a discussion of the field tasks and associated subtasks required for the sampling and sample analysis associated with the spectral gamma characterization in WMA A-AX. The tasks are generally parallel to those addressed for the vertical boreholes.

A6.0 PROJECT MANAGEMENT (TASK 1 OF CHAPTER 5.0)

Project management will be followed as described in the Phase 1 RFI/CMS work plan (DOE/RL-99-36).

A7.0 GEOLOGIC AND VADOSE ZONE INVESTIGATION (TASK 2 OF CHAPTER 5.0)

As with installation of the vertical boreholes, the geologic and vadose zone investigation task for the spectral gamma characterization has two subtasks: Subtask 2a, field activities, and Subtask 2b, laboratory analysis. The following subsections describe each of the subtasks with a field activity component.

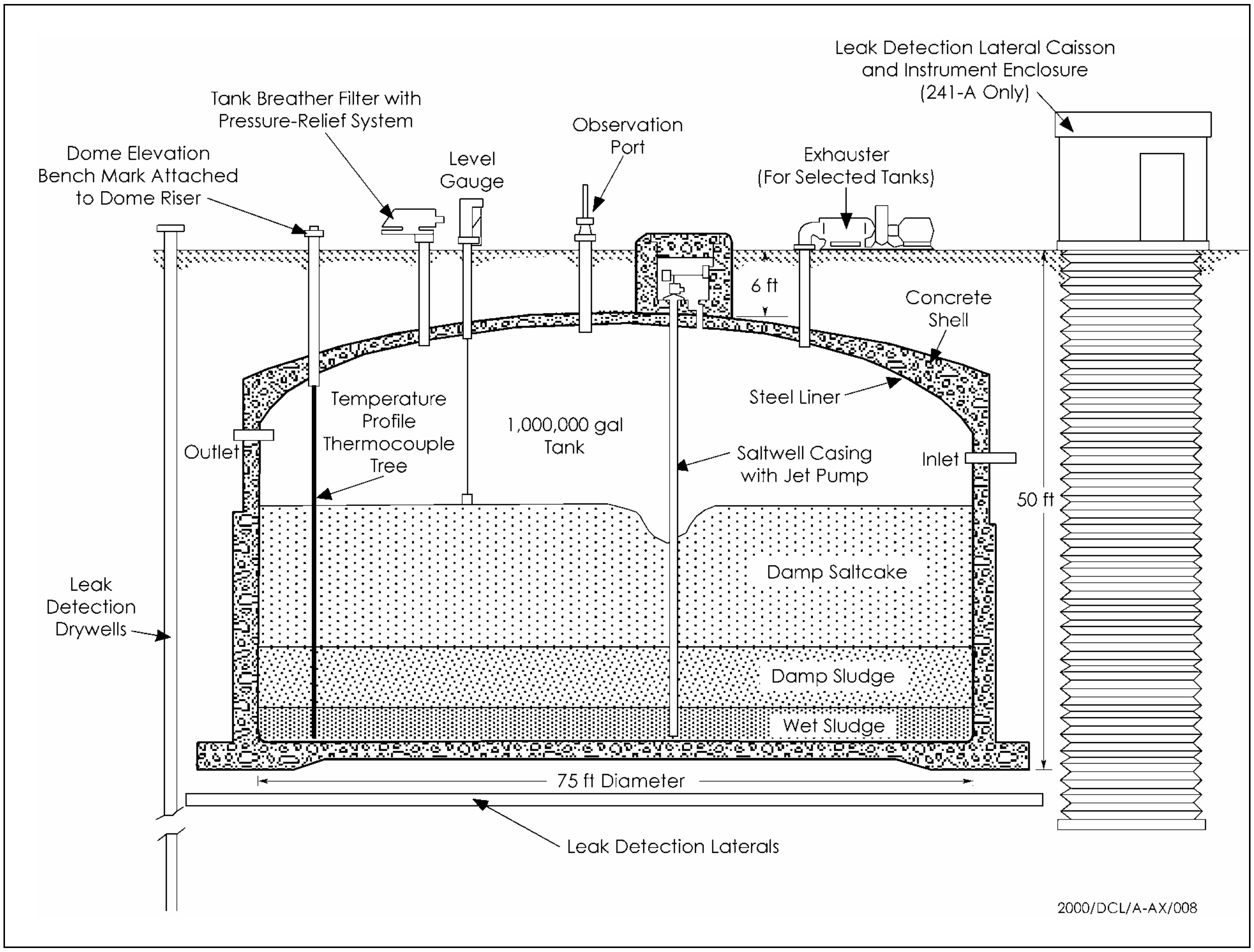
A7.1 FIELD ACTIVITIES (SUBTASK 2A OF CHAPTER 5.0)

The field activities addressed in this subtask that are required to support the geologic and vadose zone investigation are geophysical surveying, and reporting.

A7.1.1 Exploratory Activity

Loss of tank integrity for tanks A-104 and A-105 were demonstrated in 1965 by the occurrence of gross gamma measurements in several laterals (Figure A.6) that underlie these two tanks. In this report it has been concluded that a relatively small loss of tank waste to the vadose zone has occurred in each tank, a conclusion that, in the case of tank A-105, is considerably smaller than the volume estimates provided in *Waste Tank Summary Report for Month Ending January 31, 2003* (HNF-EP-0182). The basis for the smaller volume estimate is the lack of measured cesium-137 contamination in the drywells surrounding tank A-105. Given the estimated waste loading at the time of the leak, a large volume release should have distributed measurable cesium-137 over an area large enough to intersect the drywell locations.

Figure A.6. Schematic Showing the Construction of a Typical Single-Shell Tank at A Tank Farm with a 1 Mgal Capacity (after DOE/RL-88-21)



The most direct means of measuring cesium-137 in the vadose zone is to relog the laterals underlying the tanks to collect spectral gamma data. The gamma emitting radionuclides that created the initial measured radiation were short-lived fission products (e.g., ruthenium-106). The data to be collected in the relogging effort will determine the concentrations of specific gamma-emitting radionuclides still present in the vadose zone near the laterals. By now, the primary gamma-emitting radionuclide should be cesium-137. If minimal concentrations of cesium-137 are found in laterals measurements about 3 m (10 ft) from the leak location, then the released tank waste volume will be constrained to a minimal value.

A7.1.2 Geophysical Surveying Activities

Lateral gamma geophysical logging will be conducted to ascertain the gamma-emitting radionuclide concentrations.

A7.1.3 Laboratory Analysis (Subtask 2B of Section 5.0)

No laboratory analysis will be conducted under this survey of the laterals. Appropriate quality assurance and quality control procedures will be followed.

PART IV
SAMPLING PERFORMED IN CONJUNCTION WITH THE INSTALLATION OF RCRA GROUNDWATER MONITORING WELLS

A8.0 PROPOSED RCRA GROUNDWATER MONITORING WELL SEDIMENT SAMPLE ANALYSIS (SUBTASK 2B OF CHAPTER 5.0)

Drill cutting samples will be collected in conjunction with the installation of one RCRA groundwater monitoring well. The proposed RCRA groundwater monitoring well will be located north or northeast of the C tank farm. Drill cuttings will be collected from this well to total depth of borehole (i.e., basalt). Selected portions of the cuttings will be analyzed for their chemical and physical characteristics support to closure risk assessments. A detailed description of the work associated with the installation of these monitoring wells has been developed (PNNL-13024). Only details associated with analysis of sediment drill cuttings are addressed in this SAP.

Samples for analysis will be from each stratigraphic unit, stratigraphic contacts, weathered bedding structures, and lithologic facies changes.

Drill cutting samples from WMA U RCRA groundwater monitoring well already have been collected and analyzed.

A9.0 REFERENCES

ASTM, 1998, *Standard Test Methods for Materials*, American Society for Testing and Materials, West Conshohochen, Pennsylvania.

ASTM D2488, 1990, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, American Society for Testing and Materials, West Conshohochen, Pennsylvania.

DFSNW-SSPM-001, 2003, *Sampling Services Procedures Manual*, Rev. 23, Duratek Federal Services Inc., Northwest Operations, Richland, Washington.

DFSNW -WSPM-001, 2003, *Well Services Procedures Manual*, Rev. 3, Duratek Federal Services Inc., Northwest Operations, Richland, Washington.

DOE/ORP-2000-05, 2000, *Notice of Construction for Tank Waste Remediation System Vadose Zone Characterization*, Rev. 0, U.S. Department of Energy, Office of River Protection, Richland, Washington.

DOE/RL-88-21, 2001, *Dangerous Waste Permit Application Form 3; Single-Shell Tank System*, Rev. 7, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-68, 1998, *Hanford Analytical Services Quality Assurance Requirements Document*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-99-36, 1999, *Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA SW-846, 1986, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C.

HNF-4380, 1999, *Preliminary Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA S-SX*, Rev. 1A, Fluor Hanford, Inc., Richland, Washington

HNF-EP-0182, 2003, *Waste Tank Summary Report for Month Ending January 31, 2003*, Rev. 178, CH2M HILL Hanford Group, Inc., Richland, Washington.

PNNL-13024, 2001, *RCRA Groundwater Monitoring Plan For Single-Shell Tank Waste Management Area C at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-13612, 2001, *Groundwater Quality Assessment Plan for Single-Shell Tank Waste Management Area U*, Pacific Northwest National Laboratory, Richland, Washington.

P-GJPO-1783, 1995, *Vadose Zone Characterization at the Hanford Tank Farms, High-Resolution Passive Spectral Gamma-Ray Logging Procedures*, Rev. 1, U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

Resource Conservation and Recovery Act of 1976, Public Law 94-580, 90 Stat. 2795, 42 USC 6901 et seq.

RPP-7455, 2000, *Data Quality Objectives Report for Waste Management Areas T and TX-TY*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

WAC 173-160, “Minimum Standards for the Construction and Maintenance of Wells,” *Washington Administrative Code*, as amended.

WAC 173-303, “Dangerous Waste Regulations,” *Washington Administrative Code*, as amended.

This page intentionally left blank.